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Editorial

A new echocardiographic index on the horizon: Has the solution finally appeared?☆

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The echocardiographic evaluation of left ventricular (LV) systolic, diastolic and global function has been challenging, but largely used in daily clinical practice primarily due to its non-invasive nature. There are many parameters that could be used in estimation of LV function; however, many of them are not robust, difficult for calculation and/or time-consuming. Thus in light of current echocardiographic recommendations we are mostly using ejection fraction and tissue Doppler parameter for the evaluation of LV systolic function; pulsed and tissue Doppler indices (E/A, deceleration time, isovolumic relaxation time, E/e′) or color M-mode flow propagation velocity (Vp) for the assessment of LV diastolic function; two-dimensional derived longitudinal strain for the estimation of LV longitudinal mechanical function; and index of myocardial performance (Tei index) for evaluation of LV global function.

Sürücü et al have proposed a new parameter of LV global function in this issue of Indian Heart Journal.[1] The newly proposed Sürücü index is calculated by using the tissue Doppler parameters obtained from LV basal-lateral annulus level, by subtracting a′ velocity from e′ velocity and dividing it by s′ velocity [(e′−a′/s′)], which should represent the index of LV global function, estimating LV diastolic and systolic function at the same time. The investigators compared it with other well-known indices of LV diastolic and global functions.[1]

1. Evaluation of LV diastolic function

Cardiac systole and contraction represent energy-efficient process that does not require additional force. On the other hand, LV cardiac diastole is the ability of the ventricle to fill at low left atrial pressure, and it represents a highly energy-demanding process.

In daily clinical practice the ratio between early and late diastolic trans-mitral flow velocities (E/A) has been used as initial parameter of LV diastolic function.[2] However, this parameter is highly age, heart-rate- and load-dependent and also unable to differentiate normal from pseudonormal mitral inflow patterns. Actually, LV filling pattern shows a U-shaped relation with LV diastolic function, with similar values obtained in healthy subjects and patients with heart disease. In other words there is an issue in recognizing normal subjects from individuals with diastolic heart failure and preserved systolic function. The other problem appears in patients with sinus tachycardia, conduction system disease, and arrhythmias (atrial fibrillation, first-degree AV block and 3:1 or 4:1 AV block) in whom E/A should be interpreted with caution or could not be estimated at all.

Other pulsed Doppler parameters, such as mitral deceleration and isovolumic time (DT and IVRT) are also influenced by age and load condition, thus they are unable to provide an easy alternative.[2]

The Valsalva maneuver could be helpful in differentiation between normal and pseudonormal mitral inflow patterns assessed by pulsed Doppler. Namely, it decreases preload during the strain phase and changes pseudonormal mitral inflow to impaired relaxation pattern. However, not everyone is able to perform this maneuver adequately. Further, the introduction of tissue Doppler decreased the importance of this maneuver in the evaluation of LV diastolic function.

☆ This editorial is pertaining to the article: Suruci Index and Others.

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Color M-mode propagation velocity (Vp) represents an additional method of LV diastolic function estimation, and particularly in mitral-to-apical flow propagation.[2] Normal LV intracavitary filling has dominant early wave and an atrial-induced filling wave, similar to transmitral filling obtained by pulsed Doppler. However, usually only Vp is estimated for early diastolic filling wave. In the normal LV, the early Vp propagates rapidly toward the apex and is determined by a pressure gradient between the base and apex of the LV.[2] This gradient represents a semiquantitative marker of LV relaxation. In patients with heart failure and myocardial ischemia, there is slowing of mitral-to-apical flow propagation, consistent with a reduction of apical suction and Vp.[3] Investigations in patients have revealed that the ratio of peak E velocity to Vp is directly proportional to left atrial pressure. The main problems of this parameter are relatively low reproducibility and inability to predict high LV filling pressure in patients with normal LV volumes and ejection fraction.

The introduction of tissue Doppler imaging significantly improved and facilitated the estimation of LV diastolic function in daily clinical practice because it provided the assessment of systolic and diastolic function within the same cardiac cycle. Additionally, it was less load-dependent than pulsed Doppler parameters (E/A, DT, IVRT).

Tissue Doppler derived e′ velocity is a measure of LV relaxation in early diastole and is relatively load independent.[4] It could be measured from the lateral and septal segment of mitral annulus in the apical four chamber view and there is a regional variation of e′ − higher value at the lateral segments. Studies showed that e′ correlated inversely with early diastolic pressure (dP/dt) or tau (LV relaxation time constant),[5] that reflect LV relaxation and elastic recoil. Importantly, e′ velocity is reduced even in subjects with early LV diastolic dysfunction, appearing almost 10–15 years before the reduction of pulsed Doppler E velocity.[6] The hemodynamic factors that affect e′ velocity are: LV relaxation, preload, systolic function, and LV minimal pressure. Tissue Doppler obtained a′ velocity determines global atrial function and does not vary between different regions of the LV. It is also age and load-dependent, but less than pulsed Doppler A velocity. The main hemodynamic factors that affect a′ involve left atrial systolic function and LV end-diastolic pressure. An increase in left atrial contractility leads to increased a′ velocity, while an increment in LV end-diastolic pressure induces a reduction in a′.

E/e′ ratio is a good predictor of LV filling pressure, especially in patients with normal LV ejection fraction, which is why the current guidelines for the estimation of LV diastolic function emphasized its importance in the diagnostic algorithm for the estimation of LV filling pressure in this group of subjects.[2] Considering the fact that septal e′ is usually lower than lateral e′ velocity, the septal E/e′ ratio is commonly higher than the ratio derived by lateral e′. Even though septal E/e′ ratio is sometimes used in patients with globally normal or abnormal LV systolic function; it is crucial to use the average e′ velocity (septal and lateral) in the presence of regional dysfunction.[2] However, the E/e′ ratio may not be accurate as an index of filling pressure in patients with significant annular calcification, mitral valve disease (primarily significant mitral regurgitation), and constrictive pericarditis. The studies showed that E/e′ ratio was independent predictor of cardiovascular mortality in patients with heart failure with reduced and preserved ejection fraction, patients after myocardial infarction and subjects with hypertension with/without hyperinsulinaemia.

2. Evaluation of LV global function

The idea of one index that could simultaneously describe systolic and diastolic LV function existed for a long time. Tei Chuwa developed the myocardial performance index in 1995.[7] Later studies showed that the Tei index was a reliable method for the evaluation of LV systolic and diastolic performance in a broad spectrum of cardiac diseases. The calculation of this index is simple, the sum of isovolumic relaxation and contraction time divided with ejection time [Tei index = (IVRT + IVCT)/ET].

Originally, pulsed Doppler parameters were used for the calculation of the Tei index but the main disadvantage of this approach was inability to obtain ejection time simultaneously with isovolumic relaxation and contraction time. Additionally, investigations demonstrated that the Tei index was dependent on age and loading condition. On the other hand, the myocardial performance index correlated well with different parameters of LV systolic and diastolic function (ejection fraction, fractional shortening, E/A ratio); and furthermore, it was a good predictor of mortality in patients with ischemic heart disease, heart failure, heart transplant, as well as in patients with impaired function of the right ventricle.[8]

Tissue Doppler evaluation of parameters that were used in calculation of the modified Tei index significantly simplified the assessment of this useful marker of global cardiac function because they provided the estimation of all three necessary time indices (isovolumic relaxation, isovolumic contraction and ejection time) in the same cardiac cycle. Investigation that compared pulsed and tissue Doppler-derived Tei indexes revealed significant differences between these values,[9] which later reflected in the recommendations which clearly distinguish cutoff values for the Tei index assessed by these two different Doppler methods. However, tissue Doppler evaluation of the Tei index did not prevent the impact of age and loading condition; and unfortunately did not improve its reproducibility.

Sürücü and coworkers in this issue of the Journal propose a new parameter of LV global function using common tissue Doppler parameters (e′, a′, s′).[1] They calculated the Sürücü index by subtracting a′ velocity from e′ velocity and dividing it by s velocity [(e′−a′/s′)]. All tissue Doppler values have been obtained from the basal segment of the lateral LV wall. The authors reported that the Sürücü index negatively correlated with age, LV mass index and the Tei index.[1] Vp showed a negative correlation with age, while the Tei index did not correlate with age, BMI, sex and LV mass index. The investigators also claim that the Sürücü index is less affected by preload.

The idea of the index that incorporates several tissue Doppler parameters is interesting, but not completely novel. A recently published study has suggested a new tissue

Doppler index, $[E/(e' \times s')]$, which proved to be a powerful predictor of clinical outcome and cardiac death in patients with heart failure, independent of pro-BNP level, E/A and E/e′ ratios and LV ejection fraction.[10] However, the authors did not consider the influence of preload and afterload on this new index and considering the fact that two parameters are load-dependent (E and e′), it seems reasonable to hypothesize that load condition will have some impact on this new Doppler index.

The Sürücü index also comprises of two indices that are influenced by preload (e′ and a′) and s′ velocity that measures longitudinal LV contraction and represents a surrogate of LV systolic function; thus, it is likely that this index is also load dependent. The authors showed somewhat lower inter-observer variability of this index in comparison with Vp and the Tei index, and therefore Sürücü index may be more reliable. These findings encourage the investigators to use this index in the future longitudinal studies with large number of patients. These large studies should be able to answer all questions related to the effect of preload, inter- and intra-observer variability and clarify the effect of this index on cardiovascular morbidity and mortality.

In conclusion it is important to emphasize the significance of developing new Doppler indexes, preferably ones that are easier to calculate and use than the existing ones. These new indexes would be more useful in everyday clinical practice if they would be independent of age, sex, BMI, LV mass and load conditions.

Conflicts of interest

The authors have none to declare.

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